PDHonline Course P121 (4 PDH)

Project Management, Instrument & Controls Engineer

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Project Mgmt, Instrument & Controls Engineer

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Course Content

Project Engineering: 1. Engineering activities associated with designing and constructing a manufacturing or processing facility. 2 Engineering activities related to a specific objective such as solving a problem or developing a product (ISA Comprehensive Dictionary of Instrumentation and Control)

As a **Professional Engineer** it is very likely that you will be called on to participate in a project along the lines of your stated discipline, or as part of the project manager's team. In ether case it is your responsibility to know how to interact with other disciplines, the management team, and understand the tasks that will ultimately be your responsibility. The position of Lead Engineer in any of the engineering disciplines can be frustrating, but the **Lead Instrument Engineer** is probably the most frustrating of all, so be aware of the following:

- Instrumentation is the last task to be completed before a process can be started up.
- The Process & Mechanical departments must have completed 80 - 90% of their design before the instrument department can complete the following tasks:
  - Specify instrument ranges to procure instruments
  - Develop the alarm and interlock list for logic development
  - Show the location of instrument sensors on equipment layouts
  - Piping must be complete before routing of cables.
  - Calibration information has to be developed from equipment instruction manuals.
- You are not allowed to miss a scheduled document transmittal date even though you have not been able to get the required information from the Process Engineer. (Lead Instrument Engineers must be clairvoyant!)
- The other departments tend to use up the man-hours, before the instrument department is 15% complete and more often than not they are told that the budget has to be cut. (Bear this in mind when developing the estimate.)

Principle (Lead) Instrument (& Controls) Engineer:

POSITION OVERVIEW: This is an advanced supervisory or specialization level within Engineering. The Principal Engineer may supervise the discipline work of one or more projects or provide technical expertise in one or more engineering fields.

MAJOR DUTIES AND RESPONSIBILITIES: Plans, directs, and supervises the work of a major engineering unit or project requiring large-scale expenditure of manpower and financial investment. May function as project lead engineer on medium-to-large projects assuming responsibility for the work of the group. May assist section supervisors with administrative and technical duties. Determines methods and solutions for complex problems and selects the most efficient and economical manner in meeting objectives. Makes frequent interdiscipline contacts within the Company and with clients. Work is assigned in terms of broad objectives. Outlines methods of approach, critical areas, and priorities for the more junior engineers. Makes recommendations regarding policy, procedures, and staffing for personnel assigned to activity. Reports to the section supervisor or project manager should utilize PC-based systems to enhance productivity. Makes independent engineering studies, calculations, sketches, reports, analyses, specifications, interpretations and conclusions. Participates in proposal preparation, client presentations and plant start-ups. Responsible for operating within established budgets and schedules. May require routine security clearance. Performs other duties as assigned.

MINIMUM POSITION QUALIFICATIONS: Baccalaureate Degree and 10-12 years relevant experience in an engineering environment. Professional registration is a state requirement. Good interpersonal skills are important. Demonstrated supervisory potential is necessary.

Project responsibilities:

- Directing and training the Instrument department's engineers, designers, and CAD operators assigned to the project.
- Interacting with all other disciplines assigned to the project.
- Generating the Deliverables List for the instrument department.
- Interfacing with the client's instrument and project personnel.
- Developing an Instrument & Controls Scope of Work.
- Estimating man-hours and budget for the Instrument department based on the deliverables, site visits, meetings, and schedule.
- Assisting to develop an engineering schedule for the project.
- Designing, generating and compiling all instrument department deliverables.
- Checking all documentation prior to issue.
- Assisting project controls with developing a Man Power Loading matrix.
- Assisting the Process & Mechanical department in development of the P&IDs (http://www.engineeringtoolbox.com/pfd-process-flow-diagram-d_465.html) and PFDs. (http://www.water-technology.net/projects/metal_beckart/metal_beckart5.html)
- Reviewing and commenting on all other disciplines deliverables.
- Attending HAZOP reviews and providing discipline resolutions.
- Estimating Instrument equipment and construction costs.
- Resolving RFIs (Request for Information) generated by client or contractor during construction phase.

Where it begins: I caution you now…Project Managers (PMs) in many organizations are also the marketing arm of the firm; as such they try hard to please the client and be awarded a contract. The Lead must stand firm on budget and schedule if he or she is to have a successful project, it is of prime import that a good estimate and schedule are developed for all projects.

Proposal Development: An engineering estimate is always necessary and usually generated based on a client's Scope Of Work or a preliminary set of P&IDs. Each discipline (Civil, Structural, Project control, Mechanical, Process, Piping, Electrical & Instrument) develops an estimate, and then the Project Management team assembles it for presentation to the client. On large projects, teams consisting of the Project Manager and discipline leads make a combined presentation to the client so that they can get to know the individuals before a contract is awarded. If the client likes the project team and accepts the proposal he may award the contract and the project is initiated.

How it begins: The Chief Engineer usually assembles his staff of discipline leads and distributes a client's Scope of Work. He then instructs the Leads to develop:

- A **Deliverables List**, (a list of the various documentation and drawings required to provide a design package necessary to construct a facility.)

Deliverables checklist:

1. Scope of Work.
2. Design Criteria Study.
3. Process Definition
4. Sequence of Operations.
5. P&ID
6. SAMA (Scientific Apparatus Makers Association) http://ctjohnson.com/PDF/SAMA.pdf) diagrams.
7. Instrument Index.
8. Specifications, Data Sheets.
9. Specifications, CSI (Construction Specification Institute) format.
10. Input/Output (I/O) List.
11. Safety Interlock List.
12. Alarm List.
13. Electrical Elementary diagrams.
14. Loop Sheet drawings
15. Control Logic drawings.
16. Control Network drawings.
17. Computer Network drawings.
18. Graphic Display drawings.
19. Control Configuration Logic.
20. Location Drawings.
21. Control Room Layout drawings.
22. Control Cabinet Layout drawings.
23. Control Cabinet Wiring diagrams.
24. I/O Rack Layout drawings.
25. I/O Rack Wiring diagrams.
26. Field Panel Layouts drawing.
27. Field Panel Wiring diagram.
28. Installation Details Drawings.
29. CCS (Cable Conduit Schedule).
30. SLC (System Life Cycle) documentation.
31. Equipment Submittals.
32. Contractors bid package
33. Procurement documentation.
34. Instruction Manual assembly.
35. Model development man-hours.
36. As-Built drawings.

- A man-hour estimate required for developing, generating and compiling the documents and tasks in the Deliverables List.

Once the Leads develop the their individual Deliverables List, they discuss among themselves overlapping tasks and decide on responsibilities. The following is just one example of what must be determined before an estimate can be developed

- Since P&IDs are a shared responsibility of the Instrument Mechanical and Process departments. One of them must take the responsibility for the drawings and drafting. Most often in is the Mechanical department.

This is an example of the interfacing that must take place before a reliable estimate can be developed. The instrument Lead must determine exactly how he will work with the electrical Lead because of the many overlapping tasks. It is important the two Leads have a good working relationship and be physically located near each other for a project to run smoothly.

The following are a few suggestions for dividing task responsibilities between the electrical and instrument (E&I) departments. Note: On some projects the E&I Lead is the same person.

- The electrical department's main purpose is normally to provide electrical and backup services wherever necessary in the proposed facility. It then follows that they could handle electrical services to all instruments and controls including cable, conduit, tray and power distribution panels. The instrument department would necessarily keep the electrical depart informed of the instrument & control power requirements. Each discipline would review the others drawings and specification in order to be aware of requirements.
- Since the electrical department will be designing for the majority of cable and conduit, again it makes sense that they also take the task of designing for the instrument & controls portion of the project, which in most cases means making the cable tray wider and designing a divider to keep higher voltages cabling separate from low voltage instrument cable.
- The CCS (Cable Conduit Schedule) is another task that can be better handled by the electrical department with proper input from instrumentation.
- Network cabling should be handled completely by the instrument department because of the special requirements.

These are the main areas that responsibilities must be established for before beginning an estimate, however, during the life of a project there are many other give and takes that must take place that are determined in weekly project meetings.

Engineering Estimate: Now that I have introduced you to the basics for developing an estimate I want you to actually develop one by downloading a simple estimating form at http://ctjohnson.com/ZipFiles/HOEform.zip, download form and Unzip the it. It is in Excel 4.0 and titled the **Home Office Estimate** (HOE) and is used to generate engineering costs to develop priced proposals for clients. NOTE: IF THE ZIP FILE DOES NOT download by clicking on it, right click and "SAVE TARGET AS", BE SURE TO REMEMBER WERE YOU SAVED IT.

HOE form: Can be imported into most spreadsheets.

- The **ACTIVITY** column coincides with the Deliverables List and other tasks that must be considered in a total project.
- The **TASK** column assigns number that will be used in the project schedule.
- **TYPE** refers to drawing size, computer program used, or report format (Ltr=Letter).
- **QTY** refers to number of drawings, lists, specifications, reports, etc.
- The balance of columns: **ENG** (engineering), **DES** (Designer), **COMP** (computer use), **CAD** (drafting hours on CAD machines) are filled with the number of man-hours estimated to perform the tasks or generate deliverables (documentation). The spreadsheet attempts to use the QTY column to total up the man-hours based on several years of past experiences, however, every project requires fine tuning. Each task and activity must be individually adjusted if the Lead Engineer has information that would effect the man-hours of a task or deliverable.

Overhead Direct Costs (ODC): In addition to the man-hours a calculation of ODC must also be made and submitted for inclusion in the cost of the project. ODC are costs for air travel, motel room, meals, taxi, etc that may be required for client meetings, site surveys and the like. Although the HOE form shows these activities it does not allow for entry of them. Additional columns can be added to the form to account for them.

Exercise 1: After you have downloaded the estimate form please view a sample project (using Adobe Acrobat) at http://ctjohnson.com/PDF/instrdocs.pdf . The .pdf file includes the primary documents designed to be used to document I&C project

Using the HOE form make a simple estimate based on the **Drawing Index on page 5 of 14** of the project. Remember, you only have to enter the number of deliverables, P&ID drawings, Instrument data sheets and loop sheets in this exercise. The form will calculate the total Engineering-hours and total hours including overhead supervision required. The estimate along with ODC and a copy of the Deliverables List is submitted to the Project Manager and a proposal can then be made to a client.

Project Kickoff: If a project is initiated the Leads will again meet after to begin development of a schedule or review a schedule that Project Controls has already developed.

Exercise 2: Now you must develop a manpower-loading schedule from our man-hour estimate. Please download http://ctjohnson.com/ZipFiles/ManHrEst.zip and Unzip (it is in Excel 4.0). Open it with a spreadsheet program.

Manpower Loading (forecast) form:

- “B” column makes use of the numbering system from the HOE form for project control also known as charges.
- “C” column is the tasks grouped by the project control number.
- “D” column is where you enter the estimated man-hours
- “E” and “F” calculate how many hours have been used and how many are remaining to be used.
- The column balance is divided into columns of approx 80 man-hours by the calendar.
- Rows “34” & “35” calculate the man-hours used in the stated period.

The major rows are divided into “ENG” (engineering hours) and “DES” (designer hours) because on most projects an engineer (using a computer) works with a designer (using a CAD station. Using the totals in the following example,the hours would be spread to meet the project schedule and make use of the manpower available. Obviously, will not attempt to include a lesson in manpower scheduling, but I will give you an example using the estimate we have made. Fill in the form as follows (do not put figures in “Left”, it will be calculated)

MANPOWER FORECAST:

			TOTAL	HOURS		---> OCT		NOV	
CHG	TITLE		EST	USED	LEFT	15	29	12	26
330-01	Instrument Engineering	ENG	2	2	0		0	1	1
		DES		0	0				
331-01	Lists, Instrument, Alarm etc	ENG	60	60	0	24	24	12	
331-02		DES		0	0				
332/6-01	Drawings	ENG	70	70	0	24	24	16	6
332/6-02		DES	112	112	0	28	28	48	8
337-01	Programming and Configuration	ENG		0	0				
337-02		DES		0	0				
338-01	Specifications	ENG		0	0				

		DES		0	0				
101-01	Project supervision	ENG	11	11	0	4	4	3	
101-02		DES		0	0				
MANPOWER				255	0	80	80	80	15
	ENGINEER		143	143	0	52	52	32	7
	DESIGNER		112	112	0	28	28	48	8

Note, the total man-hours for weeks ending Oct 15, 29, and Nov 12 are 80 hours, that allows one person to do the engineering and design in the six-week period with some time left for resolutions to any comments or questions. In most real cases an engineer would do the engineering and work on a deferent project in the remaining hours. A Designer would do likewise. In any case you cannot schedule more hours in a specific period than manpower is available.

Scope of Work: A detailed document describing the complete project scope must be developed for client review and approval. This will define the boundaries of the project in terms of equipment to be automated. It will include a description of the automation effort. Normally it will include the deliverable list and preliminary Instrument index. This is the most important document that will be produced and must detail every activity that will be performed by your discipline. Make no assumptions! Discuss it with the other disciplines and make sure every item and event that must be performed to complete the project is set forth. Remember, every hour that you or your staff spends on a project must be accounted for. The Scope of Work must state the type of control philosophy that will be employed:

- DCS (Distributed Control System).
- SCADA (Supervisory Control And Data Acquisitioning System) & PLC (programmable Logic Controller).
- SLC (Single Loop Configurable) control system.

The type of field device communication that will be employed:

- Field bus and types, IE: ProFiBus, DeviceNet, ASi, or Foundation Fieldbus, etc.
- Analog 4-20mA or 3-15PSI.

Whether a high level Information Technology system will be incorporated:

- MIS (Management Information System)
- MES (Manufacturing Execution System)

Control System Development and Design: Only After the Scope of Work has been approved should the actual design be initiated and it will require several activities to be accomplished concurrently.

- Generate an Instrument Index to track devices and gather information from other disciplines on the process and mechanical aspects of the project.
- Determine area classifications and designing to meet the requirements.
- Identifying potential risks and defining solutions for it.
- Developing the control logic that will be used.
- Developing control and/or information networks.
- Developing Instrument Loop Sheets and Electrical Schematic drawings

- Specifying software required for the control system selected
- Specifying and sizing instrument and control devices.
- Specifying and Sizing control and safety valves.
- Updating P&IDs as the process evolves.
- Identifying and specifying control and I/O (Input/Output) locations and rooms

Instrument Index: The next step is to begin building an instrument index (refer to Instrument Documents previously downloaded Page 5 of 5) to track specifications and process information. Normally you would start with the P&ID and enter all the tag numbers along with as much information that can be gathered from a P&ID. In our sample project we have a SAMA (Scientific Apparatus Makers Association) (http://ctjohnson.com/PDF/SAMA.pdf) diagram, Please review the .pdf file for further information. SAMA was once widely used because it is great for describing the control logic, but the P&ID is now the primary source of this information. Page 2 of 8 of the Mohican project shows the actual Index used in the project and the essential information:

1. Tag number associated with the device (should be defined by ISA Standards)
2. Loop Sheet that shows how it is to be wired or tubed in a control loop.
3. Service description
4. Manufacture of the device
5. Type of device, valve, gauge transmitter, etc.
6. Model number
7. Input range for calibration
8. Output range, normally a standard signal such as 4-20mA or 3-15 PSIG.
9. Process connection material, type and size.

You may download **InstrIndx.zip**, a complete instrument index application that will run on DOS or Microsoft Windows 9X at http://ctjohnson.com/Programs.html or use the database files that were used to make the application. If you cannot make use of the DOS program please download **II-dbf.zip** and import the file instindx.dbf into a spreadsheet or database program. Review the 90 columns (fields in the database) that make up the main record. You should be able to understand why a spreadsheet is not conducive to developing an instrument index. InstrIndx is a relational database that includes much more than just the main record, it includes all the standards for developing instrument tags and can generate instrument and valve specification data sheets. Since it is based on standard .dbf files the tables can be imported into many types of spreadsheets and databases and the extent of the various parameters required for large projects can be reviewed. I will go into more depth on how an instrument index is developed in a PDHcourse later. For now you must understand the importance of the volume of information that must be maintained by the instrument discipline.

A responsible engineer will provide the client with a computer file that can be used directly or with application in order to track calibration and maintenance in the future. Many clients now demand that the Instrument Index be in a certain computer format. Do not get caught in a trap of using a program that is suppose to generate specification sheets and loop sheets right out of the database (there are several on the market). I have used two of the most popular ones and was very disappointed; they do not work well and are very expensive. My suggestion is to use a computer database or spreadsheet program that you are familiar with to develop the index and a CAD program for the loop sheets. I have also used Microsoft Excel for the loop sheets with good success.

The Instrument Specification: Once you have your Instrument Index in place you can begin generating the specification sheets used to procure the devices (refer to Instrument Documents previously downloaded pages 3 & 4). You can download **InstrSpec.zip** a typical set of them at http://ctjohnson.com/programs.html , they are in an old Lotus format but will work in Excel with a little touch up. The following is an actual copy of one of one the data sheets and they are developed by me as shareware. ISA will also provide data sheets at https://www.isa.org/default.aspx .

The column with numbers and the one to the immediate right are a part of the form, the second column to the right is the one that is filled in with information specifying the instrument or device that is required. The example above is specifying a pressure gauge. Although the Manufacture and Model number is filled in, do not be fill in the Mfr or Model until a quotation is obtained from likely vendors. Once the Manufacture is chosen from those submitting proposals it would be appropriate to complete the Manufacturer and model number, being sure to update the balance of the specification if any exceptions are made to the actual specifications. In other words, make sure the specification agrees with the Manufacturer and model number filled in before it is used to procure the device.

Specification or Data Sheets as above must contain all the necessary information required for a vendor to offer a proposal or provide the proper device. Do not rely on a Model number alone to describe the device because manufactures may make changes that that could conflict with the actual requirement. NOTE: The quantities of instruction manuals that will be require should also be in the notes are because there is often a charge for extra copies.

CSI Format: If a specification sheet (data sheet) cannot fully describe the device then a written specification must be used. A long form specification may be written and described in any suitable format; many times a **CSI** (Construction Specification Institute) format may be the best method of specifying a device. For more information go to https://www.csiresources.org/home an example follows:

SECTION 16160
CABINETS AND ENCLOSURES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Fabricate custom Control Console, install and wire PLC system components.

B. Provide NEMA 12 single door enclosure, install and wire PLC system components

1.02 RELATED SECTIONS

A. Section 16190 - Supporting Devices.

B. Section 16903 - Programmable Control System

1.03 REFERENCES

A.	NEMA -	National Electrical Manufacturer Association
	Pub. 250-1985	Enclosures for Electrical Equipment (1000 Volts Maximum).
	Pub. ICS-4	Terminal Blocks for Industrial Control Equipment and Systems.
	Pub. WC 30	Color Coding of Wires and Cables
B.	ANSI/NFPA 70 -	National Electrical Code.
	Section 250	Grounding.
	Section 310	Conductors for General wiring.
C.	ICEA -	Insulated Cable Engineers Association
	Sec. S-61-402	Part 7.4 Thermoplastic-insulated Wire and Cable for Transmission and Distribution of Electrical Energy.

1.04 SUBMITTALS

A. Proposal Submittal

1. Submit the following information with the proposal in triplicate.
    a. Control Console Fabrication drawings.
    b. NEMA 12 Cabinet manufacturer's dimensional sheets.
    c. Catalog sheets on console and cabinet hardware that will be used in fabrication and assembly.
    d. Nameplate engraving schedule and dimensions.
2. Complete and submit the attached questionnaire.

B. Contract Completion Schedule

A detailed schedule for design, programming and delivery of the console and cabinet shall be provided with the proposal. This schedule shall clearly indicate items that control delivery and the procedures proposed to insure compliance with the schedule.

C. Post-Award Submittal Material

a. The selected Bidder (Supplier) shall furnish 7 copies and one reproducible (sepia or otherwise) of all shop drawings. Four copies to be sent to Owner and three copies to Engineer.

Owner:	Mr. S. Harold Moxley, PE Senior Engineer, Production Engineering South Carolina Electric & Gas Company
Engineer:	Mr. Bryon G. Padera

D. FINAL DRAWINGS AND DOCUMENTATION

The Supplier shall provide ten (10) sets of drawings showing the actual point to point wiring of the control panels.

1.05 REGULATORY REQUIREMENTS

A. Conform to requirements of ANSI/NFPA 70.

B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.

1.06 EXTRA MATERIALS

A. Provide two of each cabinet key.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A.	Hoffman Engineering Co.	NEMA 12 enclosure
B.	States Company	600 volt terminal blocks
C.	Power Right Company	600 volt terminal blocks
D.	General Electric Company	Switches model CR104 Indicators model ET-16
E.	Burndy	Wire terminators

2.02 CABINET

A. Steel, Free standing, NEMA 12, single door with full mounting plate equal to Hoffman model A-723618FS.

B. Provide metal barriers to separate compartments containing control wiring operating at less than 50 volts from power wiring.

2.03 CUSTOM CONSOLE

2.04 TERMINAL BLOCKS

D. Signal and Control Terminals: Modular construction type, suitable for channel mounting, with tubular pressure screw connectors, rated 300 volts.

E. Provide ground bus terminal block, with each connector bonded to enclosure.

2.05 ACCESSORIES

A. Plastic Raceway:

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify conditions under provisions of Section [01039] [_____].

B. Verify that surfaces are ready to receive Work.

3.02 INSTALLATION

A. Install Products in accordance with manufacturer's instructions.

B. Install enclosures and boxes plumb. Anchor securely to wall and structural supports at each corner.

C. Install cabinet fronts plumb.

END OF SECTION

The **CSI** format is not easy to implement without using the **CSI** software because of the numbering and indention method employed, however, the information given is a good rule to follow even though it is really directed at a Contractors use because of its three part sections:

Part 1 General: includes relative Sections, Standards, References, Schedules, Submittals, Documentation requirements and Required Warrantees

Part 2 Products: List approved manufactures and fully Describes the device, or building

Part 3 Execution: Describes the method to use to build or erect the device or building (many times this section reiterates the information in Part 2), **DO NOT Repeat information already given elsewhere in any document if at all possible because when revisions are made, most often, repeated information is NOT corrected and ultimately leads to conflicts.**

Transmittal form: Once the specifications are generated they must be transmitted to other members of the project for their comments and including in their design. They must also be transmitted to the client for his comments. To this end a Transmittal form that includes everyone that should get a copy is usually developed by project management and distributed to the team. You may download a usable copy of Transmit.zip at http://ctjohnson.com/Programs.html, Unzip it and open in a spreadsheet. The following is an example:

Date: 01/19/04	Job & File No.:	Sheet 1 of 1
To: person or dept xyz company addr addr city, st, zip	Subject: Project Name Client's Order No.:	Distribution List: (X) With Enclosure(s) (XX) Transmittal Only

R. Macklem	X	H. Cooper	X
J. Hendricks	X	H. Niehaus	XX
C. Rutherford	X	E. Ziegler	XX
C. Johnson	X		
D. Morris	X		
R. Akins	X	V.P.File	X
B. Biggers	X	File 3.8.1	XX

Enclosed:		These:		For:		Please:	
	List	X	Are Preliminary		Information		See Below
	Prints		Have No Exceptions		Reference		Revise
	Originals		Have Exceptions Noted	X	Review and Action	X	Comment
	Reproducibles		Are Final		Staking		Review and Return
	Purchase Order		Are For Revision As Noted		Contract		Acknowledge
	Specifications		To Be Revised As Noted		Construction		Destroy Old Issues
	Reports/Manuals				Construction Revision		File
	Diskette(s)				Property		Return On Completion of Job
	Other				Property Acquisition		Revise & Resubmit

No. of Copies	DOCUMENT OR DRAWING NUMBER	DESCRIPTION	REMARKS

Revise as noted and return _______ signed certified copies and ________ reproducibles of each print.
Please advise within 10 days of any change in the contract price and/or changes in delivery due to these changes.
Your revised quotation should include a listing of all changes with itemized prices and the total contract price including this change.
Your quotation must be prepared in ________ copies addressed to ____________________

Please acknowledge receipt of enclosures and return one copy to sender:	PARSONS MAIN, INC.
RECEIVED BY: N/A Date	BY: ____________________

The **transmittal form** is not to be taken lightly; it is a necessary document in all projects. Do not send information, drawings, specifications, or any other deliverable to ANYONE without a transmittal accompanying it. All to often a contractor or client, or worse yet one of your own team members, will misplace the document and you will wind up in a very uncomfortable situation if you do not have the transmittal to show that the document was indeed sent.

Input/Output (I/O) List: This list is actually developed in the Instrument Index and printed out as a report. Most field devices will generate an output signal such as 4-10mA, 3-15 PSIG, or have a network ID if the are networked with a field bus. This should be entered in the instrument index. Depending on the type of control used there will be input information from the field and it is good practice to inter this information in the Instrument Index associated with the actual field device. On large systems you will find out the importance of tracking this type information in a database by associating all I/O in a common document.

Safety Interlock List: This listing should also be associated with the instrument Index, however it is not easily done. You must develop an "I" (Interlock) numbering system that can be stated in the borders of P&IDs to show the interlock scheme and some can be quit complex. In many situations a logic diagram of the scheme must be generated to account for the associations. Any device that is part of the scheme should have it's "I" number included in the Instrument index as such.

Alarm List: This is another one that should be generated as a report from the Instrument Index. The Index should have fields for up to six alarm points per device. In many cases the Control Engineer assumes the actual points will be set in the field during startup, but he should really try to establish them in discussions with the Process Engineer ahead of time.

Electrical Schematics: If there is an Electrical Engineer on the team the Control Engineer may not be required to develop schematics unless there is relay logic or a Safety Interlock system that requires them. In my sample project for Mohican Mills I did generate ILS-004B for motor controls and ILS-006B for coal handling logic.

Instrument Loop Sheet: Now that we have the instruments specified and tag numbers assigned in our Instrument Index we can begin to develop connection diagrams. Unlike Electrical drawings that are shown in schematics or Single Lines, Instruments and controls are generally developed in a control loop that includes all devices that are dependent on each other and must be calibrated in the "LOOP". In large projects each control loop is relegated to a single Loop Sheet and tracked by the associated instrument Tag Number.

For a real LOOP SHEET developed for a control valve operated on a field buss (AS-I network) and drawn in Microsoft Excel go to http://ctjohnson.com/Programs.html and download **LoopSht.zip.** The LOOP Sheet has been scaled to print out on 11X17" paper which is the standard for this type drawing.

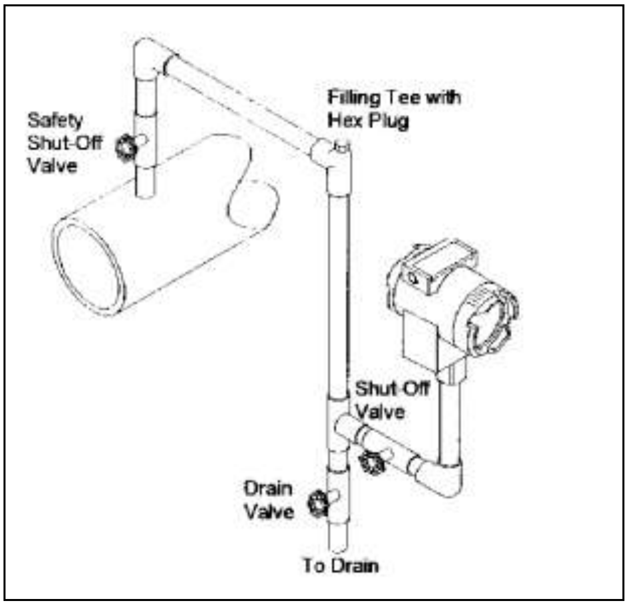
Control and Computer Networks: Most of us are familiar with a network drawing that shows routers, hubs, servers and clients such as: http://www.blackbox.com . You will have to develop a drawing showing every networking component and make sure one is for high level networks and, more importantly, a field bus network.

Graphic Displays: the newer DCS and SCADA systems require graphic screens to be developed. It is best to use the actual software to develop the screens, then print them and forward to the client (with a transmittal) for approval. Some clients are very particular of the colors and symbol used, be sure to determine these requirements before spending time to develop than. A good start to developing an overall graphic is the P&ID that many programs will allow you to import from a CAD file. A rule of the thumb to follow is to limit the number of active points on a graphic screen to 20 based on operator feedback experience

Location Drawings: The example Documents do not include these drawings, however, a large project would require the Control Engineer to mark up the Equipment Layout drawings produced by the process or mechanical dept with a bubbled tag for each field instrument to show it's approximate location. Obviously this is a step that must take place after the equipment arrangements have been formalized. These drawings should most often be “D” size.

Control Cabinet and Junction box Terminations: Drawings use a actual physical layout and point-to-point termination method. This method is preferable to a schematic layout because it augments installation and maintenance. It certainly aids with troubleshooting by phone. However, if costs reduction were necessary the loop sheets and schematics would suffice for wiring.

I/O Rack Layout and Wiring: In the example documents show a modern day system which normally requires I/O cabinets and racks.



Installation Details: The example does include installation details and most large projects do require them. The one below is taken from a mfr’s instruction manual and does not go into enough detail:

Although it shows the requirement for shutoff valves and piping a Installation Detail must specify the mfr. and model of the valves, fittings and other components required for the complete installation. DO NOT rely on mfr instruction manuals, use them as good start and copy the information, but be sure to list all components necessary for a contractor to procure and install correctly.

CCS (Cable, Conduit Schedule):. Usually, the Electrical department handles the CCS with the instrument department’s help. It can also be included with the Instrument Index and printed as a report. Again it is a very important deliverable for the contractor, however, it is difficult to calculate the cable lengths precisely.

System Development Life Cycle (SDLC): Once upon a time, software development consisted of a programmer writing code to solve a problem or automate a procedure. Today’s systems are so big and complex that teams of architects, analysts, programmers, testers and users must work together to create the millions of lines of custom-written code that drive our enterprises. A tutorial on the subject can be found at https://en.wikipedia.org/wiki/Systems_development_life_cycle

Equipment Submittals: Now comes the point in the project that the specifications have been sent out for bid and proposals have been received along with catalog cuts and possible exceptions to the specifications. Hopefully most manufactures have responded timely and meet the specifications and requirements. By this time in the project preliminary drawings have been checked for submittal and a contractors bid package is being assembled.

Contractors Bid Package: Large projects will require a package consisting of the deliverables be sent to several contractors for bidding purposes. It is always wise to have final documents available for the contractors, but, not always feasible. Make sure if preliminary drawings or documents are sent in this package that they are clearly marked as such. DO NOT allow project management to talk you into removing the PRELIMINARY stamp under any circumstances.

Procurement Documentation: Project management will handle most of this, but usually want a form that indicates the quantity and types of instruction manuals and certified drawings or prints that are required. Quantities of manuals should be a part of the specifications you sent out for bid since often times there is a charge for extra manuals.

Instruction manual assembly: Following procurement instruction manuals are normally sent to the engineering firm for assembly with other documentation and final drawings for distribution to the favored contractor.

As-Built Drawings: Not always a requirement, but most large jobs require this activity to be performed and drawings "Cleaned" up before they are finally transmitted to the client.

Model Development: This activity is becoming a normal requirement and can be a tough one for the Instrument discipline to complete. It is not a great help for instrumentation except for routing of cable tray and setting up main control rooms. In the long run if completed properly a few deliverables could be deleted, such as location drawings.